

The Influence of Salinity on the Distribution of Two Oregon Chiton Species (*Katharina tunicata* Wood and *Mopalia hindsii* Reeve)

by

DAVID C. ROSTAL¹ AND LEONARD SIMPSON

Portland State University, Department of Biology, Portland, Oregon 97207, U.S.A.

Abstract. Adult individuals of *Katharina tunicata* and *Mopalia hindsii* were tested for osmotic stress tolerance and oxygen consumption rates in a series of salinities (120, 100, 80, 60, and 40% seawater). *Katharina tunicata* and *M. hindsii* displayed similar trends in percent body weight variation, volume regulatory responses, and oxygen consumption rates to osmotic stress. *Katharina tunicata* exhibited a significantly greater increase in body weight than did *M. hindsii* in response to hypoosmotic conditions (80, 60, and 40% seawater). Both species showed reduced oxygen consumption rates and significantly increased weight gain in 40% seawater. Salinity was measured twice monthly at two study sites. Salinity measurements revealed a difference in mean salinity between study sites of 12% seawater. Variation in dominant macroalgal species between study sites reflected published dietary characteristics: *K. tunicata* feeds on *Hedophyllum sessile*, while *M. hindsii* feeds on *Gigartina* spp. and animal material. Salinity appears not to influence the distribution of adult *K. tunicata* and *M. hindsii*. The results of this study suggest that both species are osmoconformers with equivalent volume regulatory capabilities and are weakly euryhaline. Other factors such as diet, larval settling responses, and interspecific competition may be involved in the difference observed in the distribution of *K. tunicata* and *M. hindsii*.

INTRODUCTION

The effect of salinity on the physiology and ecology of marine mollusks is receiving increased attention. PROSSER (1973) stated that marine mollusks are osmoconformers with various degrees of stenohalinity. More recent evidence suggests that many marine mollusks—e.g., *Littorina neritoides* Linnaeus, *Collisella digitalis* (Rathke, 1833), *Tectura scutum* (Rathke, 1833), *Modiolus* spp., and *Mopalia muscosa* (Gould, 1846)—possess mechanisms for active volume regulation and are euryhaline (BURTON, 1983).

The physiology of several chiton species has been investigated. BOYLE (1969) studied the survival of *Sypharochiton pelliserpentis* (Quoy & Gaimard, 1835) exposed to osmotic stress conditions and concluded that this species could osmoconform to salinities ranging from 50 to 150% seawater. *Cyanoplax hartwegii* (Carpenter, 1855) can osmoconform over a salinity range of 75 to 125% seawater and is capable of volume regulation (MCGILL, 1976). En-

vironmental acclimation to varying salinity was observed to influence osmotic stress tolerances between two populations of *Nuttallina californica* (Reeve, 1847) (SIMONSEN, 1976). The osmotic concentration of hemolymph in *Katharina tunicata* (Wood, 1815) fluctuated with tidal fluctuation in osmotic concentration but did not vary during exposure to air (STICKLE & DENOUEX, 1976). STICKLE & AHOKAS (1975) postulated that *Mopalia muscosa* is less susceptible to osmotic stress than *K. tunicata*. Variations in temperature and salinity from normal seawater also influence oxygen consumption in *Mopalia lignosa* (Gould, 1846) (LEBSACK, 1976).

Chitons occur along rocky shores in the intertidal and subtidal zones in all seas and latitudes (HYMAN, 1967). ANDRUS & LEGARD (1976) compared the habitats of 12 chiton species along the California coast and concluded that surf strength, light exposure, substrate composition, moisture, and biological associates were all important in determining habitat selection. PIERCY (1987) observed differences in the diet and microhabitat of six eastern Pacific chiton species and suggested that mechanisms such as resource partitioning or "indirect commensalism" may help maintain chiton diversity.

¹ Address reprint requests to David C. Rostal, Department of Biology, Texas A&M University, College Station, Texas 77843.

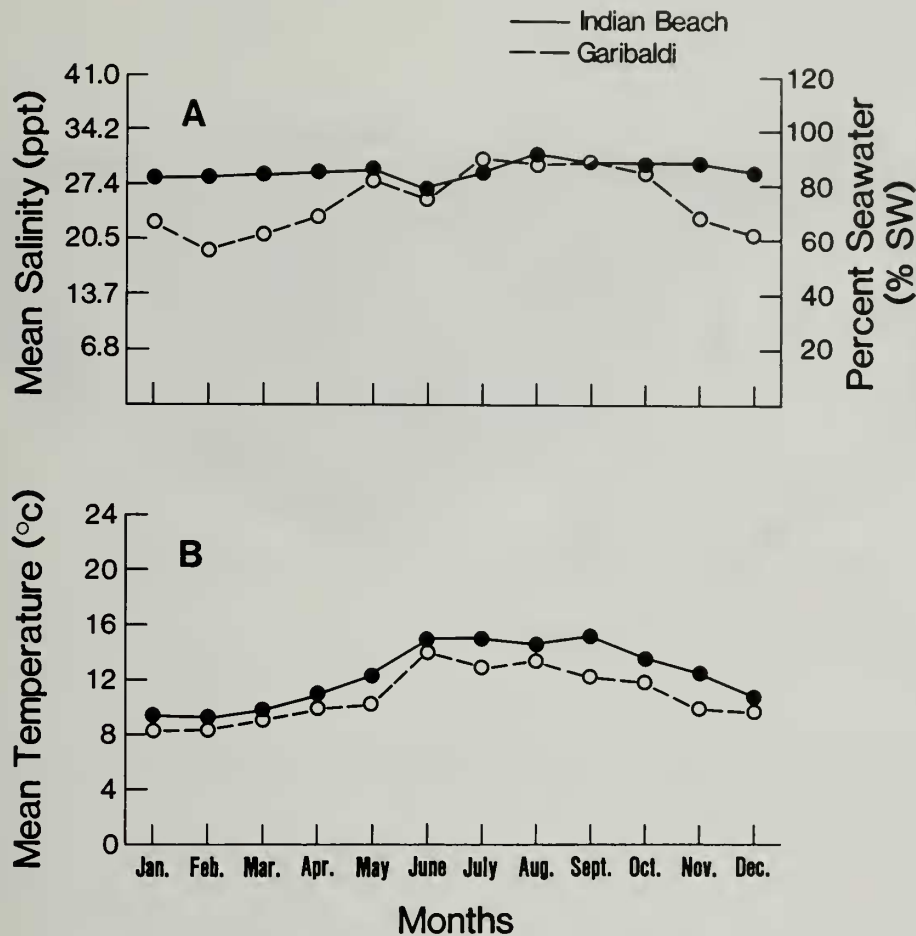


Figure 1

Mean monthly salinity (A, ppt) and mean monthly water temperature (B, °C) for Indian Beach and Garibaldi study sites. Maximum measured salinity and temperature variation was ± 5.76 ppt and 2.94°C for Indian Beach (n averaged 62 measurements per month) and ± 14.69 ppt and 5.70°C for Garibaldi site (n averaged 15 measurements per month).

In this study, the influence of salinity on distribution was investigated in two sympatric chiton species, *Katharina tunicata* (Wood, 1815) and *Mopalia hindsii* (Reeve, 1847). *Katharina tunicata* is generally restricted to open coast habitats and is considered stenohaline, while *M. hindsii* is common to open ocean as well as slightly brackish habitats and is considered euryhaline. The objectives of this research were to compare the osmotic stress tolerance, volume regulatory capabilities, and influence of salinity on oxygen consumption rates in these two species. These results will be discussed with regard to variation in distribution and ecology.

MATERIALS AND METHODS

Study Sites

An open coast and a brackish water study site were chosen for *Katharina tunicata* (Indian Beach, Ecola State

Park, Oregon) and *Mopalia hindsii* (Garibaldi, Tillamook Bay, Oregon) respectively. Site selection was based on salinity and temperature characteristics as well as intertidal indicator species.

Indian Beach, Ecola State Park, Clatsop County, Oregon ($45^{\circ}55'\text{N}$) has a large rock and boulder outcrop at the south end of the beach where wave action is strong. *Katharina tunicata* is common in this location with *Mopalia hindsii* and *Tonicella lineata* (Wood, 1815) also present. Other common open coast organisms present are *Pisaster ochraceus* (Brandt, 1835), *Mytilus californianus* Conrad, 1837, *Hemigrapsus nudus* (Dana, 1851), and *Pollicipes polymerus* (Sowerby, 1833). Mean annual salinity is 29.06 ppt (85% seawater) and mean annual temperature is 12.4°C (Figure 1, Seaside Aquarium Data; BOURKE & GLENNE, 1971).

Garibaldi, Tillamook Bay, Tillamook County, Oregon ($45^{\circ}34'\text{N}$) has a shale outcrop with small to large loose

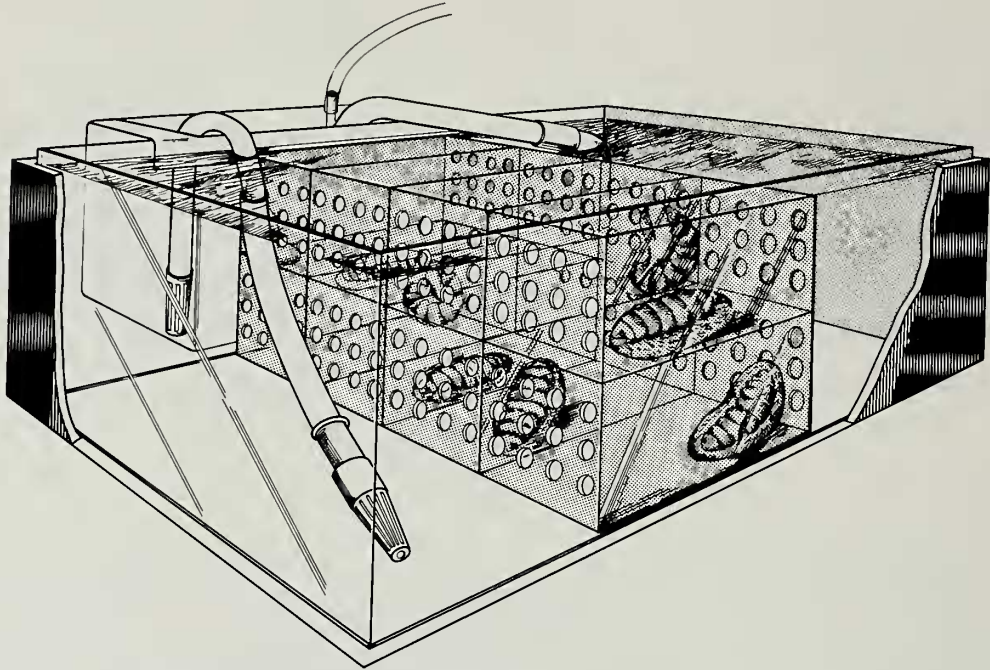


Figure 2

Osmotic stress test apparatus used to measure osmotic stress tolerance and volume regulatory rates of adult *Katharina tunicata* and *Mopalia hindsii*. Specimens (8 per test) were held in individual chambers that allowed free movement and continuous circulation of seawater.

rocks at the north end of the bay and weak wave action. *Mopalia hindsii* and *Mopalia muscosa* are found under the rocks and in crevices during low tide. Other common brackish water organisms present are *Hemigrapsus oregonensis* (Dana, 1851), *Mytilus edulis* Linnaeus, 1758, *Pagurus* spp., and *Thais emarginata* (Deshayes, 1839). Mean annual salinity is 25.47 ppt (75% seawater) and mean annual temperature is 10.9°C (Figure 1, data from the State of Oregon, Department of Environmental Quality, Portland, Oregon).

Osmotic Stress Tests

Adults of *Katharina tunicata* (mean weight = 10.23 g) and *Mopalia hindsii* (mean weight = 10.90 g) were collected at study sites and acclimated in 34 ppt synthetic seawater (100% SW, Instant Ocean Synthetic Sea Salts, Aquarium Systems, Inc.) at 11°C and 16L:8D photoperiod for two weeks prior to testing. Eight animals of each species were exposed to a test salinity (120, 100, 80, 60, and 40% SW) for 36 h in an osmotic test apparatus (Figure 2). Animals were fully submerged in individual chambers which allowed free movement and continuous circulation of seawater. Test salinities were based on the natural range observed at the study sites. At time intervals of 0, 1, 2, 4, 6, 8, 12, 24, and 36 h, animals were removed from the chambers, blotted dry with absorbent towels, and then weighed using a Mettler PC 2200 scale to the nearest 0.01

g. Animals were allowed 5 min to re-adhere in the chambers before being resubmerged in the test salinity. Percent body weight changes due to osmotic stress gradient and volume regulation were calculated.

Oxygen Consumption Tests

Oxygen consumption rates of each species were measured using a modified Scholander respirometer (SCHOLANDER, 1950). Four animals of each species were monitored in each test salinity (120, 100, 80, 60, and 40% SW) for 3–4 h at 11°C and 16L:8D photoperiod following 48 h of acclimation to the test salinity (normally post-osmotic stress testing). Oxygen consumption rates ($\mu\text{L/g/h}$) were calculated for each species per salinity.

Habitat Characteristics

Seawater samples were collected twice monthly at the two study sites during low tide from January to June 1985. Salinity (ppt) of seawater samples was determined using a YSI-33 Salinity-Conductivity-Temperature (S-C-T) Meter.

Dominant macroalgal species were collected from each study site and identified (SMITH, 1969; GUBERLET, 1956). Macroalgal species present at study sites were compared with published diets of the chitons (STENECK & WATLING, 1982; HADERLIE & ABBOTT, 1980).

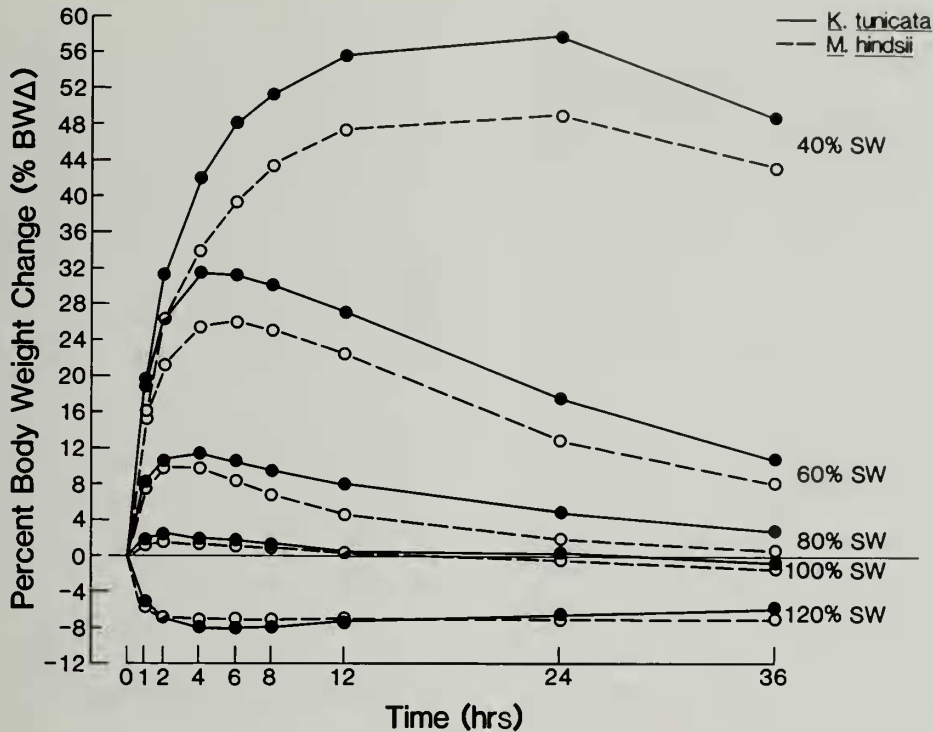


Figure 3

Mean percent body weight change and volume regulatory rates of adult specimens of *Katharina tunicata* and *Mopalia hindsii* in various test salinities over a 36-h test period at 11°C and 16L:8D photoperiod. SE was always less than 1.86% for *K. tunicata* and 2.84% for *M. hindsii*; $n = 8$ per salinity per species.

Statistical Analysis

Significant differences in osmotic stress response between *Katharina tunicata* and *Mopalia hindsii* were analyzed using a multifactor analysis of variance (repeated measures, $P < 0.05$; WINER, 1971).

Significant differences in oxygen consumption rates between *Katharina tunicata* and *Mopalia hindsii* were determined using an independent t -test ($P < 0.05$; BRUNING & KINTZ, 1977). Significant differences in oxygen consumption rates between salinities within each species were analyzed using an analysis of variance (completely randomized design, $P < 0.05$; BRUNING & KINTZ, 1977).

RESULTS

Osmotic Stress Tests

Adults of *Katharina tunicata* and *Mopalia hindsii* displayed similar trends in percent body weight (% BW) variation and volume regulatory responses to osmotic stress (Figure 3). *Katharina tunicata*, however, exhibited a significantly higher percent body weight increase than did *M. hindsii* in response to hypoosmotic conditions (80% SW, d.f. = 1,14, $F = 6.13$, $P < 0.05$; 60% SW, d.f. = 1,14, $F = 16.85$, $P < 0.005$; 40% SW, d.f. = 1,14, $F = 17.89$,

$P < 0.001$). Following maximum percent body weight variation, both *K. tunicata* and *M. hindsii* displayed similar volume regulatory rates. Maximum percent body weight variation was measured within 4 h of exposure to 120, 100, 80, and 60% seawater (Table 1). Maximum percent body weight variation in 40% seawater, however, was not reached until 24 h following exposure (*K. tunicata* = $57.91 \pm 1.57\%$ BW, $n = 8$; *M. hindsii* = $49.32 \pm 1.86\%$ BW, $n = 8$). Both species appeared to display reduced activity and adherence capabilities in 40% seawater compared with other salinities tested.

Table 1

Maximum percent weight change for two Oregon chiton species (*Katharina tunicata* and *Mopalia hindsii*) in various salinities. Results are mean values \pm SE (n).

% SW	<i>K. tunicata</i>	<i>M. hindsii</i>
120	-7.899 ± 0.181 (8)	-7.165 ± 0.248 (8)
100	2.276 ± 0.156 (8)	1.835 ± 0.325 (8)
80	11.456 ± 0.402 (8)	10.000 ± 0.527 (8)
60	31.423 ± 0.739 (8)	26.115 ± 0.907 (8)
40	57.906 ± 1.573 (8)	49.321 ± 1.864 (8)

Table 2

Oxygen consumption rates ($\mu\text{L/g/h}$) for two Oregon chiton species (*Katharina tunicata* and *Mopalia hindsii*) in various salinities. Results are mean values \pm SE (*n*).

% SW	<i>K. tunicata</i>	<i>M. hindsii</i>
120	11.9 \pm 2.2 (4)	10.6 \pm 2.3 (4)
100	13.5 \pm 1.3 (4)	12.7 \pm 1.2 (3)
80	11.3 \pm 0.6 (4)	11.7 \pm 2.9 (4)
60	10.6 \pm 1.7 (4)	12.4 \pm 2.7 (4)
40	5.7 \pm 0.9 (3)	7.6 \pm 1.0 (4)

Oxygen Consumption Tests

Oxygen consumption rates in each salinity were not significantly different between *Katharina tunicata* and *Mopalia hindsii* (Table 2). *Katharina tunicata* and *M. hindsii* displayed similar trends in response to various salinities (Figure 4). The mean rate of oxygen consumption by *K. tunicata* decreased significantly with the decrease in salinity to 40% seawater (d.f. = 4,14, $F = 3.24$, $P < 0.05$). The mean rate of oxygen consumption by *M. hindsii* also decreased similarly in response to a decrease in salinity to 40% seawater; however, this decrease was not statistically significant. The reductions in mean rates of oxygen consumption in 40% seawater by both *K. tunicata* and *M. hindsii* reflect the trend observed in body weight variation and decrease in activity observed during the osmotic stress tests.

Table 3

Dominant macroalgal species of Indian Beach, Ecola State Park and Garibaldi, Tillamook Bay study sites. ** indicates presence.

Macroalgal species	Indian Beach	Garibaldi
Rhodophyta		
Crustose coralline alga	**	
<i>Bossiella orbigniana</i> (Dec.) Silva, 1957	**	
<i>Gigartina exasperata</i> Harvey & Bailey, 1851		**
<i>Gigartina volans</i> (C. Ag.) J. Agardh, 1846		**
<i>Gracilaria verrucosa</i> (Huds.) Papenfuss, 1950		**
<i>Gymnogongrus linearis</i> (C. Ag.) J. Agardh, 1851	**	
<i>Iridaea cordata</i> (Turn.) Bory, 1826	**	**
<i>Plocamium oregonum</i> Doty, 1947	**	
<i>Prionitis lanceolata</i> (Harv.) Harvey, 1853	**	
<i>Prionitis linearis</i> Kylin, 1941	**	
Phaeophyta		
<i>Fucus distichus</i> Linnaeus, 1767	**	**
<i>Halosaccion glandiforme</i> (Gmel.) Ruprecht, 1851		**
<i>Hedophyllum sessile</i> (C. Ag.) Setchell, 1901	**	
<i>Laminaria dentigera</i> Kjellman, 1889	**	**
Chlorophyta		
<i>Ulva taeniata</i> (Setch.) Setchell & Gardner, 1920		**

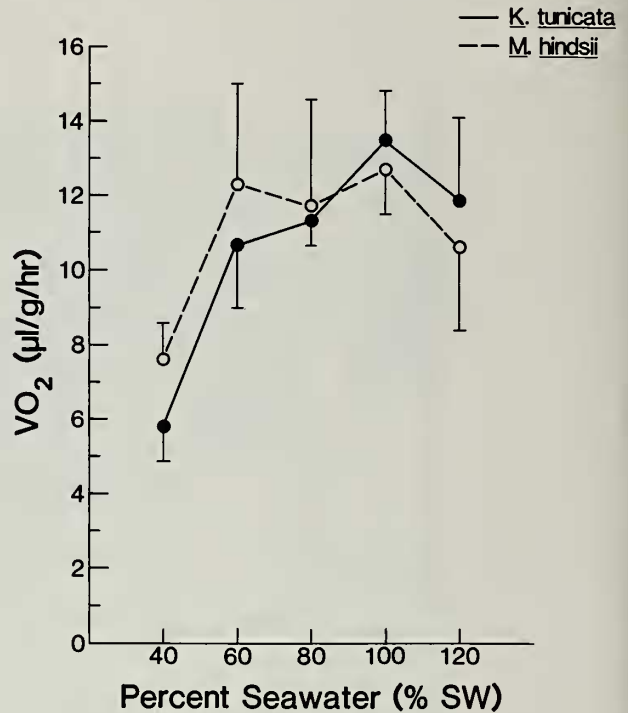


Figure 4

Mean oxygen consumption rates (VO_2) of adult specimens of *Katharina tunicata* and *Mopalia hindsii* in various test salinities at 11°C and 16L:8D photoperiod. Results are mean values \pm SE.

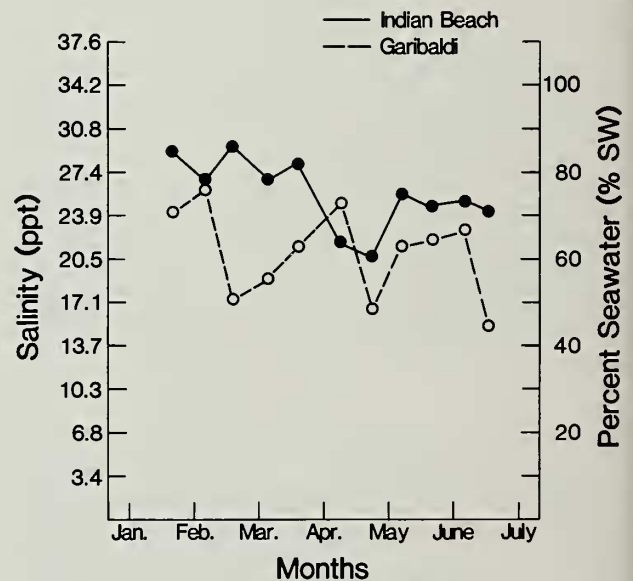


Figure 5

Twice-monthly salinity measurements collected during low tide ($n = 1$) from January to June 1985 for the Indian Beach and Garibaldi study sites.

Habitat Characteristics

Salinity measurements at low tide from January to June 1985 yielded a mean salinity of 25.63 ± 0.85 ppt, $n = 12$ (75% seawater) for the Indian Beach study site and a mean salinity of 21.04 ± 1.05 ppt, $n = 12$ (63% seawater) for the Garibaldi study site. Although mean salinities recorded during the study were lower than the mean annual salinities for the study sites (Indian Beach, 29.06 ppt; Garibaldi, 25.47 ppt), the variation in mean salinities between study sites during the study (4.59 ppt, 12% seawater) parallels the variation in mean annual salinities (3.59 ppt, 10% seawater). Measurements were taken at low tide during winter and spring months when freshwater runoff from coastal land is greatest.

Identification of dominant macroalgal species revealed variation between the Indian Beach site (six Rhodophyta, three Phaeophyta) and the Garibaldi site (four Rhodophyta, three Phaeophyta, and one Chlorophyta) in the species present (Table 3). *Hedophyllum sessile*, common in the diet of *Katharina tunicata* (STENECK & WATLING, 1982), was identified at the Indian Beach site only. *Gigartina* spp., common at the Garibaldi site, as well as animal material are reported as common in the diet of *Mopalia hindsii* (STENECK & WATLING, 1982; HADERLIE & ABBOTT, 1980).

DISCUSSION

The influence of salinity on the distribution of *Katharina tunicata* and *Mopalia hindsii* appears to be minimal. Although *K. tunicata* displayed significantly higher variation in percent body weight than did *M. hindsii* in response to hypotonic stress conditions (80, 60, and 40% SW), both species displayed similar rates of weight gain and volume regulation in all salinities tested. Both species, however, exhibited markedly increased weight gain in response to 40% seawater compared with other salinities tested. The percent weight changes observed for both *K. tunicata* and *M. hindsii* in 60–120% seawater are similar to those reported for *Cyanoplax hartwegii* in 75–125% seawater (MCGILL, 1976). BOYLE (1969) tested the osmotic stress tolerance of *Sypharochiton pelliserpentis* in 0–150% seawater and found the species tolerant of salinities ranging from 50 to 150% seawater. The response of *S. pelliserpentis* to 50% seawater, however, was similar to that observed for *K. tunicata* and *M. hindsii* in 40% seawater. The results support the hypothesis that *K. tunicata* and *M. hindsii* are osmoconformers with volume regulatory capacities and that they are similar in osmotic stress tolerance to *S. pelliserpentis*, *C. hartwegii*, and *Nuttallina californica* (BOYLE, 1969; MCGILL, 1976; SIMONSEN, 1976). The volume regulation observed is probably a “passive” mechanism rather than “active” since the size of the specimen appears to influence the rate of regulation (*i.e.*, larger specimens display slower rates of volume regulation).

LEBSACK (1976) reported that deviation in salinity from that of normal seawater results in a decrease in oxygen consumption rate by *Mopalia lignosa*, although the salin-

ities LEBSACK (1976) tested ranged only from 90 to 120% seawater. Oxygen consumption rates for *Katharina tunicata* were observed to decrease significantly in response to salinity variation from 100% seawater, while oxygen consumption rates of *M. hindsii* did not. Both *K. tunicata* and *M. hindsii* displayed equally reduced mean oxygen consumption rates in response to 40% seawater. This reduction in oxygen consumption in 40% seawater paralleled the increased weight gain observed in the osmotic stress tolerance results.

The variation in mean salinity (4.59 ppt, 12% SW) during low tide observed between the Indian Beach and Garibaldi study sites from January to June 1985 is within the physiological tolerances of both *Katharina tunicata* and *Mopalia hindsii*. The increase in body weights and decrease in oxygen consumption rates of *K. tunicata* and *M. hindsii* in 40% seawater dilution, and their reduced adherence capabilities, suggest that this salinity is near or below the ecological tolerances of both species even though it is physiologically tolerable under laboratory conditions. Salinities below 40% seawater were not measured at either study site. Although *K. tunicata* is capable of tolerating 40% seawater for a limited time, the data suggest that *M. hindsii* may be more tolerant of this extreme dilution. BOYLE (1969) reported that *Sypharochiton pelliserpentis* could survive dilutions of up to 50% seawater for at least 24 h. SIMONSEN (1976) suggested that long term acclimation to variation in salinity may influence osmotic stress tolerance in *Nuttallina californica*. Thus, acclimation may account in part for the observed variation in osmotic tolerance to extreme dilution (40% SW) between *K. tunicata* and *M. hindsii*.

The diets of *Katharina tunicata* and *Mopalia hindsii* may influence the difference observed in distribution. *Hedophyllum sessile*, common in the diet of *K. tunicata*, is restricted to open coast habitats such as the Indian Beach site (HIMMELMAN, 1978; STENECK & WATLING, 1982). Common components of the diet of *M. hindsii*, several *Gigartina* spp. plus animal material, are less restricted and are common at the Garibaldi site (HADERLIE & ABBOTT, 1980; STENECK & WATLING, 1982). Further research on diets of chitons as well as the influence of herbivory on macroalgal species under controlled conditions is needed.

BOYLE (1969) suggested that microhabitat osmotic fluctuations are unlikely to limit the distribution of *Sypharochiton pelliserpentis* owing to its euryhaline characteristics. The data support a similar conclusion for *Katharina tunicata* and *Mopalia hindsii* in that both are euryhaline and display similar physiological capabilities.

Although the influence of salinity on the distribution of adult *Katharina tunicata* and *Mopalia hindsii* appears to be minimal, salinity may indirectly influence distributions in two ways: (1) the tolerance to osmotic stress of larval stages may vary significantly; and (2) the influence of salinity on macroalgal species may affect the settling responses of chiton larval stages. For example, *Tonicella lineata* larvae display a selective settling response to the crustose coralline

algae *Lithothamnium* spp. and *Lithophyllum* spp. (BARNES & GONOR, 1973).

In conclusion, our results suggest that *Katharina tunicata* and *Mopalia hindsii* are osmoconformers with equivalent volume regulatory capabilities and that they are weakly euryhaline. Other factors such as diet, larval settling responses, and interspecific competition may influence the differences observed in the distribution of *K. tunicata* and *M. hindsii* along the Oregon coast.

ACKNOWLEDGMENTS

I would like to thank Joel Ito and Katie Simons of the Oregon Regional Primate Research Center for their assistance with the graphics in this manuscript. I would also like to thank Gerald M. Bell of the Oregon Department of Environmental Quality for his technical assistance and use of the salinity meter. My thanks are also extended to Drs. David Owens and Paul Weldon for their helpful criticism and review of this manuscript. Finally, I thank the Portland State University Research Foundation for their assistance with research and publication costs.

LITERATURE CITED

- ANDRUS, J. K. & W. B. LEGARD. 1976. Description of habitats of several intertidal chitons found along the Monterey Peninsula of central California. *Veliger* 18(Suppl.):3-8.
- BARNES, J. R. & J. J. GONOR. 1973. The larval settling response of the lined chiton *Tonicella lineata*. *Mar. Biol.* 20: 259-264.
- BOURKE, R. H. & B. GLENNE. 1971. The nearshore physical oceanographic environment of the Pacific Northwest coast. Reference 71-45, Department of Oceanography, Oregon State University, Corvallis, Oregon.
- BOYLE, P. R. 1969. The survival of osmotic stress by *Sypharochiton pelliserpentis* (Mollusca: Polyplacophora). *Biol. Bull.* 136:154-166.
- BRUNING, J. L. & B. L. KINTZ. 1977. Computational handbook of statistics. Scott, Foresman and Co.: Glenview, Illinois.
- BURTON, R. F. 1983. Ionic regulation and water balance. In: A. S. M. Saleuddin & R. M. Wilbur (eds.), *The Mollusca*. Vol. 5. Physiology 2. Academic Press: New York.
- GUBERLET, M. L. 1956. *Seaweeds at ebb tide*. University of Washington Press: Seattle.
- HADERLIE, E. C. & D. P. ABBOTT. 1980. Polyplacophora: the chitons. Pp. 412-428. In: R. H. Morris, D. P. Abbott & E. C. Haderlie (eds.), *Intertidal invertebrates of California*. Stanford University Press: Stanford, California.
- HIMMELMAN, J. H. 1978. The reproductive cycle of *Katharina tunicata* Wood and its controlling factors. *Jour. Exp. Mar. Biol. Ecol.* 31:27-41.
- HYMAN, L. H. 1967. *The invertebrates*. Vol. VI. Mollusca I. McGraw-Hill Book Co.: New York.
- LEBSACK, C. S. 1976. Effect of temperature and salinity on the oxygen consumption of the chiton *Mopalia lignosa*. *Veliger* 18(Suppl.):94-97.
- MCGILL, V. L. 1976. Response to osmotic stress in the chiton *Cyanoplax hartwegii*. *Veliger* 18(Suppl.):109-112.
- PIERCY, R. D. 1987. Habitat and food preferences in six eastern Pacific chiton species (Mollusca: Polyplacophora). *Veliger* 29:388-393.
- PROSSER, C. L. 1973. *Comparative animal physiology*. W. B. Saunders Co.: Philadelphia.
- SCHOLANDER, P. F. 1950. Volumetric plastic respirometer. *Review Sci. Instru.* 21:378-380.
- SIMONSEN, M. 1976. Response to osmotic stress in vertically separated populations of an intertidal chiton, *Nuttallina californica*. *Veliger* 18(Suppl.):113-116.
- SMITH, G. M. 1969. *Marine algae of the Monterey Peninsula*. 2nd ed. Stanford University Press: Stanford, California.
- STENECK, R. S. & L. WATLING. 1982. Feeding capabilities and limitation of herbivorous molluscs: a functional approach. *Mar. Biol.* 68:299-319.
- STICKLE, W. B. & R. AHOKAS. 1975. The effects of tidal fluctuation of salinity on the hemolymph composition of several molluscs. *Comp. Biochem. Physiol.* 50A:291-296.
- STICKLE, W. B. & G. J. DENOUX. 1976. Effects of *in situ* tidal salinity fluctuations on osmotic and ionic composition of body fluid in southeastern Alaska rocky intertidal fauna. *Mar. Biol.* 37:125-135.
- WINER, B. J. 1971. *Statistical principles in experimental design*. McGraw-Hill Book Co.: New York.